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**5G - A Revolutionary Technology for Communication**

2G was the first time that allowed users to text on mobile devices; 3G has brought us the internet and 4G delivers higher speed on data transmission that people are enjoying today. However, as more users and devices sharing the same range of bandwidth, 4G is almost reaching to limitation of capability of a time when users want faster speed and more data for their smart phones and devices, which results in an urgent needs for 5G, the fifth generation of cellular wireless network. It provides vastly increased capacity, higher speed frequency, lower latencies and a more reliable connection. With these features of 5G, downloading a high-definition movie from smart phones will take less than one second and people’s life and internet experience will be much different from it is today.

One of the core technologies involved in 5G is millimeter waves, which are extremely high frequency radio waves with the range from 30 to 300 GHZ. The higher frequency waves are, the shorter the wavelength is, making the beam narrower and transmission process faster. The frequency of the current 4G network is below 6 GHz; since the amount of online users and devices are growing in a fixed range of spectrum, it becomes very crowded and would greatly slows down services and drop connections. In order to solve the problem, 5G expended an empty session of spectrum that has never been used for mobile devices, ranging from 30 to 300 GHz. By doing that, the network will be able to provide more bandwidth for devices and relieve the intensity of the current situation.

However, millimeter waves tends to be absorbed by plants and rains and it cannot travel through walls or large obstacles. In order to solve the problems caused by the features of millimeter waves, the solution is to increase the densification of small cells in service areas such as on the streets, inside of buildings and even in our home. They perform like mini base stations with only a few inches long, send and receive data in a small range of areas. As more small cells deployed, signals can still transmit properly even when encountering large objects by going around it due to the high coverage of small cells. Looking into the 5G network architecture, it actually performs with the existing 4G network system, where 5G and 4G macro base stations are both active in operation, working with a large coverage of 5G small cells as well as central and local servers in order to provide faster transmission speed to users and lower latency performances. With the structure of 5G network, users will never drop connection from the service and they will be automatically connected to small cells when travelling one area to another.

Another technology involved in 5G is MIMO. MIMO stands for Multiple-Input Multiple-Output, which allows the transmitting and receiving of more than one data signal simultaneously over the same radio channel.[i] By utilizing a technology called beamforming, 5G station sends a focus stream of data to a specific user, instead of broadcasting information in every direction at once. With signal processing algorithm, a 5G signal processor can triangulate a user’s exact position based on the signal’s frequency, decaying degree, and direction. Therefore, this precision prevents interference, increases cell capacity, and is way more efficient.

The differences between 4G and 5G is that 5G uses millimeter waves with band range from 30 – 300 GHz. The shorter waves generate faster speed and can significantly reduce traffic, allowing more users online at the same time, while 4G only covers frequencies below 6 GHz. In addition, 5G has lower latency, with only 1 to 5 millisecond response time while 4G needs 20 to 30 milliseconds. Besides, the peak data rate for 5G is 20 Gb/s, which is much faster than 4G network in terms of processing data. The structure of the two network is different as well. 4G network mainly reply on high power cell towers to broadcast signals through long distances while 5G have small cells and towers working at the same time, providing a larger coverage service area and more continuous connections.

Beyond all the theory and technology sides about 5G, the application of 5G is also a significant topic. The development of 5G mobile communication is the area that firstly came to reality, which has also become a global race among all big nations. Take the leading countries for example. South Korea is the one claiming to be the pioneer of wide installation of 5G. Samsung is the major provider of 5G base stations to South Korea operators, and it has launched wide commercial consumer services on April fifth, twenty nineteen. US, a little bit behind South Korea, has installed 5G services in certain parts of Chicago and Minneapolis among 30 cities to be applied 5G in this year, provided by Verizon. However, Verizon hasn’t announced which cities will be on the list, so we currently have no knowledge of its specific applications. China, different from other countries, developed 5G under government guidance. Large-scale networks have been deployed in dozens of cities including Beijing, Shanghai, and Shenzhen. Hence, China Mobile claims to have the world’s largest 5G trial network.

Like all the other technologies, 5G also has its significant dark side. As discussed above, the millimeter wave has limited range due to its high frequency. According to the tests of 5G service, the signal can only reach 500 meters from the tower. Besides, millimeter waves also cannot penetrate obstructions and can be absorbed by rain and plants, which needs the deployment of 5G stations every 2 to 8 buildings in the city.

Therefore, the cost is of great concern. Without government subsidy, operators can hardly install that so many 5G stations under the cost of 4G stations. As a result, a lot of negotiations and business among government, operators, and industries are going on with a market of about 50 billion dollars.

Health issues, like always, is a problem of the technology. Due to the ultra-high frequency and ultra-high intensity of millimeter waves, the radio frequency radiation would have more serious threats to human body compared to 4G. Besides, the more densified deployment of small cells around people will make everywhere covered with similarly dense radiations.

Besides, the security of 5G is discussed widely. Since 5G has not faced web attack yet, we do not know whether or not 5G is more vulnerable than 4G. However, it will eventually connect many more devices, so protection from malign actors becomes a larger concern. For instance, the U.S. and some other nations fret that Chinese 5G equipment, chips and software could be outfitted to spy on customers in other countries.[vi] Hence, president Donald Trumps actually signed many policies boycotting imported 5G technologies, which slowed the pace of US’s 5G development.

Lastly, there is also a huge market for some future applications. While now 5G is mainly applied to mobile phones, there are a lot of other mobile devices that can apply 5G technology. For example, wearable devices and applications like running apps e.g. Fit or Keep. In the past, there is noticeable latency which compromises the precision of our exercise. With 5G smart watch, however, people can monitor their body conditions and exact position more accurately.

Further, automatic car is a field that will widely apply 5G. By calculation, a connected car traveling at 75 m/hr would travel over 10 feet (3 meters) further before applying the brakes if the system was experiencing a 100-millisecond delay. And that’s a lot. Human life can be saved with low latency applied in automatic car, which is super significant.

AR and VR, the future world of entertainment and information exchanging, will also be impacted dramatically. If you’ve played Pokémon Go, you must have noticed that the AR is not so fluent when you are using a 4G outdoors, because the 3D modeling and algorithm need to process hugeous amount of data. 5G can solve that problem, and hence many new outdoor AR games or apps can be developed.

Today, real-time translation can already be achieved with AI application. However, many translations would happen under scenarios when you are outdoors, like traveling abroad. By wearing a smart earphone, 5G connection will ultimately allow people to understand any foreign language without any delay, which makes our communication much more efficient.

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